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MARS AND ITS INHABITANTS.

BY CAMILLE FLAMMARION.

I HAVE upon my table a good many letters from various countries, inquiring of me whether, in the present state of science, we cannot form some idea as to the conditions of life upon the surface of the planet Mars, and the nature of the beings who might inhabit this neighboring world. I have always hesitated to reply to these letters because the solution of the problem is complex, difficult, and cannot be made entirely satisfactory. But a letter recently received from the NORTH AMERICAN REVIEW does me the honor to press for an answer. It would be ungracious to play the deaf mute. I accordingly comply, and I will endeavor again to discuss, with the aid of the latest lights of science, the question which I have already many times touched upon in my works. These new lights are, however, at best but feeble, and insufficient to warrant anything more than an attempt.

I.

IT IS not that we have not already reached certainty upon many points. Thus, for instance, we know that the years of Mars, almost twice as long as ours, are composed of 686 days, 23 hours, 30 minutes, and 41 seconds, and surely nothing need be more precise. We know also that the duration of day and night, or, to speak more exactly, that of the diurnal rotation, is 24 hours, 37 minutes, 22 seconds, and 65 hundredths of a second. We know further that, since the inclination of its axis of rotation is 24° 52′, the seasons there are sensibly of the same intensity as upon our planet. Besides, with our own eyes we see the polar snows melt during the summer and reappear in the winter.

Furthermore, we know very exactly the geography of this neighboring globe, and in this respect there is hardly any more mystery for us than in its calendar. We have observations and detailed drawings of its continents, its seas, its streams, its islands, its capes, the mouths of its great rivers, and its canals—there is not, one might say, a single point upon the surface of Mars which has not been the object of perpetual study on the part of various observers.

Still further; we know also the density of this globe as well as the intensity of gravity upon its surface, and these are two dominating elements in the organization of its living residents. The whole globe of Mars, which has a diameter of about half that of the earth (528 thousandths—6,728 kilometres or 4,281 miles), weighs only 105 thousandths of our globe, or 625,584 quintillions of kilogrammes. The density of the materials which compose Mars is inferior to that of the substances which compose the Earth, in the proportion of 711 to 1,000. If we compare this density with that of water, for example, we find that the mean density of the Earth is five and a half times (5.50) greater than that of water, or in other words, our globe weighs five and a half times as much as a globe of water of the same dimensions. But Mars weighs not quite four times (3.91) as much as a globe of water of its dimensions. Its component substances are then less dense than ours.

Once more, gravity there is much less powerful than upon the Earth, in the proportion of 376 to 1,000; that is to say, that a mass of 1,000 pounds transported to Mars, and there weighed by a spring-balance, would weigh only 376 pounds, and that a man weighing 160 pounds upon the Earth would weigh only 60 pounds upon the surface of this neighboring globe. Here we have absolute data, demonstrated mathematically and indisputable—data with which imagination has nothing whatever to do. Let us now pass on to consider the planet's climates and atmosphere.

II.

MARS is more distant from the sun than the Earth is, in the ratio of 152 to 100. Its distance is 226 millions of kilometres (140 millions of miles), while that of the Earth is only 149 (93 millions of miles). The quantity of heat received from the central luminary of our system is therefore less than half as much as here; it amounts only to 43 hundredths of that which we receive upon the Earth.

Are we, then, to suppose that the mean temperature at the surface of the planet is lower than here? It is probable, because, on the one hand, this globe receives not quite half as much of solar radiation as we do; and because, on the other hand, its atmosphere is lighter, more rarefied than ours. Since gravity at its surface is much less than at the surface of the earth (0.376), all bodies then weigh less in the same proportion, and the atmosphere comes under the same rule. If each square yard of the surface of Mars supported a similar atmosphere to ours, the presence of this Martian atmosphere would be reduced in the proportion stated above—that is to say, the barometer on Mars, instead of standing at 30 inches at the sea level, as upon the Earth, would there indicate only 11.28 inches. This is the pressure which we find in a balloon at an elevation of 8,000 metres (26,250 feet), and this elevation is that of the highest mountains. At the summit of Mt. Blanc the barometric pressure is 16.69 inches.

The habitual clearness of the Martian atmosphere is additional evidence of this rarefaction; clouds and condensations hardly ever form in it. Such an atmosphere does not retain the solar heat so well as ours, but permits it more easily to radiate and dissipate itself in space.

It is then *probable* that there the temperature is lower than upon the Earth; but we add immediately that it is not *certain*, because if the Martian atmosphere were constituted a little differently from ours this would suffice to make it operate very efficaciously upon the solar heat, and retain it as in a hot-house.

Water-vapor suspended in the atmosphere keeps in this heat incomparably better than dry air. It is also the same with the vapor of the ethers, sulphuric, formic and acetic, with the vapor of amylene, iodine, ethyl, chloroform, bisulphide of carbon, etc., etc. Extremely rarefied as it is, the atmosphere of Mars might certainly hold in suspension vapors of this sort, and thus maintain upon the surface of the planet a temperature equal to the mean temperature of the Earth, or even higher.

At any rate the difference of climates is not very great: it is doubtless a little cooler there than here—that is all. If the atmosphere there did not behave in the way we have indicated, we should have upon the planet the temperature of mountains clothed with eternal snow, and its surface would be perpetually frozen from the equator to the poles. Now, observation proves to us that the climates of the planet are much more temperate. The snow-caps which form around the poles during the long winters—winters twice as long as ours—melt almost completely under the warmth of the summer. This summer heat must then be rather powerful to effect such a fusion. The polar snows of Mars melt even more completely than do our own, either because the heat stored up during the long summer really acquires a very considerable intensity, or because the sheet of snow has very little thickness. We have here a settled fact of observation. During the last summer of the southern hemisphere of Mars between the months of July and November, 1894, we saw, at our observatory of Juvisy, the polar snow-cap shrink from a diameter of three thousand kilometres to four hundred. There remained finally only a mere point, so to speak, a little on one side of the geographical pole.

Moreover, one sometimes, in the winter, observes snowfalls of considerable extent, which likewise melt rapidly. In the month of April, 1890, for instance, Mr. Pickering photographed a fall of snow upon Mars which covered an area of 2,500,000 square miles a surface almost equal to that of the United States.

The thermometry of the Martian atmosphere does not appear to differ essentially from ours, but as this atmosphere is less dense han ours, certain differences follow of necessity. The boiling, point of water, for instance, must be below 212° F., as is the case upon our high mountains, because this point depends on the atmospheric pressure; every one knows that on the summit of Mont Blanc water boils at 184° F. The freezing point on Mars is perhaps not the same as here, since the water there can hardly be identical with ours in chemical composition. Each different substance has its own point of congelation and its own point of evaporation. While water solidifies at 32° F., mercury becomes solid only at 40° below zero; alcohol vaporizes at 172.4° F.; wood spirit at 149.9°; sulphuret of carbon at 116.6°; sulphuric ether at 100°, etc. We must not be in haste, therefore, to infer the identity of Martian meteorology with terrestrial. It may be that snow on that planet is formed not at 32° F., but at a temperature a little lower.

We are accustomed in the climates of the Earth to a definite temperature. The mean annual temperature of Paris, for instance, is 50° F., and between summer and winter the temperature oscillates between 32° and 68° F., overpassing these mean limits, however, rather frequently. From the equator to the poles each country of the globe has its own climate, depending upon its latitude, upon its distance from the ocean (which tends to equalize all temperatures), upon its elevation above the level of the sea, upon the prevalent regimen of winds and clouds, etc., etc.

Plants, animals, men live in each climate in a medium with a temperature to which they are accustomed. They feel cold when the temperature falls below this normal mean, hot when it rises above it. But these effects are relative and not absolute. Beings accustomed to live in Siberia, at a usual temperature only a few degrees above the freezing point, get along perfectly well in it, while others living within the tropics consider a temperature of 25° C. (77 F.) extremely agreeable. We make a gross blunder if we assume that the inhabitants of Mars, whatever sort of creatures they may be, must have the temperature of Moscow, of Paris, of Caracas, in order to be comfortable. They may have temperatures entirely different, lower or higher, and yet feel themselves to be under natural conditions, with normal surroundings.

Let us now remark that the Martian meteorology is less complicated and more pleasant than that of the Earth. There the weather is almost always fine, especially during summer. Very seldom are there clouds even in winter. Generally when we are unable to distinguish through the telescope the details of the geographical configurations upon the planet the fault is in our own atmosphere and not in that of Mars. It is very rarely the case that when our atmospheric conditions are good we are unable to see these details. During the last period of observation of Mars in 1894, I, to speak for myself, encountered only fifteen days (from October 10 to 25) when the surface of the planet was veiled by its own atmosphere. Clouds are excessively rare on the surface of Mars, and perhaps exist at all only as fogs or light cirrus : they are not clouds of rain or storm. These veils are very infrequent there while they are perpetual upon the earth. Probably there is not a single day in the year when the entire surface of the earth is uncovered so that it could be satisfactorily observed from space. The two planets have two meteorological systems that are absolutely antithetical.

Furthermore, in the rarefied atmosphere of Mars there can be no powerful winds, like the trade-winds and the predominant atmospheric currents which rule terrestrial climates. Occasionally, however, observers have noted long streaks of snow which appear to have been produced by currents in a tranquil atmosphere. Schiaparelli, for instance, observed such streaks (" *trainées* ") in November and December, 1881, around the northern pole, and extending a considerable distance from it. But such things are exceptions. *The normal condition upon Mars is fine weather.*

After what has preceded, we may consider ourselves virtually transported to this little neighbor world with full knowledge of its conditions of habitability. It remains to add a few words upon its topographical and geographical organization, and our " visit " will be finished.

III.

WHILE three-quarters of the globe of the Earth are covered with water, the seas occupy only about half of the surface of Mars. There are no great oceans like the Atlantic, the Pacific and the Indian Ocean : only Mediterraneans, long and narrow. The northern hemisphere is almost wholly dry land. All the seas are situated in the southern hemisphere, chiefly on one side, that which contains the prime-meridian, and between the longitudes of 260° and 60°.

The depressions which are covered with water occupy this region mainly ; the opposite hemisphere is a little more elevated. It is somewhat the same upon the Earth, for Europe and Asia extend towards the North, while the great oceans extend southward. But we note upon Mars a very great difference from the Earth besides that of the extent of the seas : it relates to their depth. Not only are the Martian seas less extensive, they are also very shallow. In a great number of places they are hardly more than marshes, sometimes dry and sometimes overflowed. Many tracts along the seashore are at times covered with water and completely inundated. Moreover, at certain moments of most satisfactory observation it seems as if one could see the bottom of the sea. It would probably be no exaggeration to say that over half of the Martian seas the depth of the water is only a few fathoms.

The mechanism of the distribution of the water in the atmosphere and on the surface of the globe of Mars is not at all the same as here. Here the mechanism is sufficiently simple. All quarters of the globe are covered with water, the evaporation is considerable, the atmosphere is dense, the solar heat removes continually a great quantity of water from the surface of the seas, raises it in the state of vapor to a certain height where it condenses into clouds, and there the winds, which are strong because of the density of our atmosphere, transport these clouds over the continents. Resolving itself into rain or snow, the water thus transported gives birth to springs, to streams and rivers, which return to the ocean the water that had been removed.

Things do not go this way on our neighbor. The evaporating surface of the Martian seas is far less extensive than here. The solar heat there is only about half as much. But on the other hand the seasons are twice as long. The waters, less deep than ours, can become more easily warmed during the summer and evaporate as upon the Earth. The snow can extend itself around the poles during the long winter, and finally the heat of the long summer may be sufficient to melt almost completely the snow-sheet, which doubtless is not very thick.

Direct observation proves that the snow-sheet does melt almost entirely (something which never happens upon the earth) and sometimes very rapidly.

It is this fusion of the snow which rules the water circulation. No clouds, no rains, no springs, no streams, no rivers carry back water of precipitation to the sea.

The snows begin to melt long before the summer solstice (we see it from the earth). This melting produces almost always extensive inundations, which we also see from here. Sometimes hundreds and thousands of square kilometres are overflowed, and the sea coast is pushed forward into the land. Then an ingenious system of "canals" (whatever they may be, natural or artificial) distributes and regulates these waters over the whole surface of the continents. As the water arrives the canals become visible, at first narrow and pale, but soon wide and dark.

These canals may be natural furrows, produced in the very process of the planet's evolution, like the English Channel and the Channel of Mozambique upon the Earth, or they may be grooves excavated by the inhabitants for the distribution of the water, or they may be both; that is to say, natural formations improved by intelligence. What is certain is that they serve to give circulation to the waters, and constitute a hydrographic system of extreme ingenuity. One might object that this fine system does not prevent inundations. No, but it regulates them. It is a "rise of the Nile" controlled and directed.

The periodical inundation caused in each Martian summer by the melting of the snows is distributed far and wide by the network of canals, which constitutes the principal mechanism—if it is not the only one—by which water, and, with it, organic life, can be diffused over the planet's surface. At this time some of the canals appear to be bordered by a darkish fringe, due, without doubt, to some kind of vegetation. The canals of the surrounding region become, at the same time, darker and broader, and cover wide areas. Things remain in this condition until the moment when the polar snows are at their minimum. Melting has ceased. The width of the canals diminishes, the dark regions brighten up, and the continents resume their yellow color. This grand phenomenon takes place over the whole region between the pole and the sixtieth degree of latitude and recurs each season. Over the whole surface of the planet the system of canals is variable. When they are indistinct and their contours become uncertain and ill-defined it seems likely that the water in them is very low, or may have entirely disappeared. Nothing is left of the canal, or rather we see only a yellowish streak, differing very slightly from the surrounding soil. In the months which precede and in those which follow the great northern inundation, about the time of the equinoxes, the canals become double; in consequence of a rapid change, which is effected in a few days, perhaps even in a few hours, this or that canal is transformed in all its length into two parallel lines, which run with the geometric precision of the tracks of a railway, and follow exactly the direction of the original canal. These new canals have, like the original ones, widths of from fifty to a hundred kilometres, and even more, and are separated by an interval varying from fifty to five or six hundred kilometres. We have here something besides water; for instance, a rapid vegetation produced by the moisture. From the height of a balloon the prairies, which occupy the slopes on each side of a river, mark out the course of the river, which itself appears like a slender thread, hardly differing in color from the green ribbon beside it. The color of the double canals upon Mars varies from black to red, and is easily distinguished from the yellow tint of the continents. The space between them is generally yellow, sometimes whitish. The gemination occurs also in the lakes, which divide into two.

Whatever may be the explanation of these facts, unparalleled upon the earth, we are able to conclude that upon the surface of the planet Mars the water circulates, not by a system of clouds, of rains, and springs as here, but by the melting of polar snows, and by a system of canals, horizontal and intersecting, which distribute it over the whole extent of the continents. Then it evaporates, to be condensed almost entirely in the cold polar regions, which re-collect it in the state of snow.

It is obvious from this entire array of physiological conditions that the world of Mars is a world vigorously alive, offering both analogies and contrasts with our own. In this present state of our knowledge can we scientifically form for ourselves any theory as to the nature of its inhabitants ?

IV.

THIS question of the state of life upon other worlds involves all the sciences, as has been already evident from the preceding discussions. It is a question of natural history, of zoölogy, of physiology, of paleontology, of chemistry, of physics, as well as of astronomy. It invites us first of all to inquire how life made its appearance on our own planet, what are the laws which have directed its development, and why the human race, to which we belong, is constituted as it is. If we consider the aggregate of terrestrial life we notice in it three grand divisions : the inhabitants of the waters, the dwellers upon the ground, and the winged tribes. The forms, the dimensions, and the structure of these different species depend upon the medium which they inhabit, upon their specific gravity, and the manner of their nourishment. The beings which do not eat, as the plants, have no alimentary canal. One can conceive of plants without roots, able to move like animals, and living on air : beings without digestive organs, without stomach, without bowels, resembling us in no respect. This essential difference of structure would not prevent these beings from living, from feeling, or from thinking. That would be evidently quite another world.

In a medium illuminated by an entirely different light from ours, more distant from a sun, or receiving the rays from a sun of color red, blue, green or violet, or in which the rays were infra-red or ultra-violet, our eyes would not be at all what they now are. The sense of sight would be replaced by another, which would see what now we cannot see. We might not have two eyes in the countenance, but perhaps three, or only one ; or even, doubtless, a wholly different kind of visual organ.

Each of our six senses (everybody knows the sixth sense) has been formed and developed gradually since the primordial period of terrestrial life. In place of six we might have seven, eight, ten, twenty, fifty. We have received only those with which *terrestrial* nature has supplied us.

Every form, animal and vegetable, is determined in its medium and by its medium, as the fossils testify clearly and irrefutably. At first the waters covered all the globe, and then there was no terrestrial animal that breathed by means of lungs.

To have wings, that is a very great advantage : the birds hold a rank above us. Upon the earth the progress of thought has been wrought out through the mammals. The lions, tigers, bears, horses, dogs, and apes, the wild men of the paleolithic caves, have all preceded us. If the birds had been worked out to perfection in this progression the human soul would have dwelt in some winged form, instead of being embodied in a form that cleaves to the earth.

Gravity, and the density of the materials of which they are composed, play a great part in determining the organization of beings. In the bosom of the sea, animals lose a portion of their weight equal to that of the volume of water which they displace, and they can therefore, without much inconvenience, attain the colossal dimensions of the whales. It could not be so on solid ground where the elephants already meet with some difficulty in moving. Gravity opposes a limit to the size of creatures.

It is this which prevents the birds from reaching a stature comparable to that of men. Eagles, vultures, condors seem to be at the limit.

If the attraction of the earth were less powerful our winged tribes might have received a much greater development. In virtue of the unquestionable principle known as "the struggle for existence," these winged creatures, dominating all others, would have been the strongest. Progress would have been effected along this line. The superior race, the human race, would have been a winged race. These simple considerations, which it would be easy to extend much farther, are enough to convince us that our human form is essentially terrestrial, and that the inhabitants of Mars cannot resemble us. They are *different.*

Upon Mars, for example, one might suppose, without scientific heresy, that the remarkable lightness of their bodies may have developed the winged race more highly in the direction indicated, and that the inhabitants of this planet may have received the privilege of flight.

Does this amount to saying that, for this reason, they must necessarily have the form of birds ? No. The bats, are they not mammals which suckle their young ?

Is it saying, then, that we must imagine them under this form ? Not at all. May they not rather be like dragon-flies fluttering in the air above the lakes and the canals ?

As to this point we can imagine everything and prove nothing. It is even highly probable that the reality is something absolutely different from all our terrestrial conceptions.

On the one hand the lightness of the Martian beings is favorable to their winged constitution. On the other hand, however, the atmosphere is hardly well fitted to sustain them. But still we recall that terrestrial zoölogy furnishes instances of birds, which are very heavy, such as the condors and the vultures, and these are just the ones which fly highest in the most rarefied regions of our atmosphere; they have been observed even above the summits of the Himalayas, the Andes and the Cordilleras at elevations of from 8,000 to 9,000 metres (27,000 to 30,000 feet) where they can still soar freely, thanks to the enormous spread of their wings.

Nor must we lose sight of the fact that a human being weighing 70 kilogrammes (154 pounds) would weigh no more than 26 kilogrammes (56 pounds) if transported to the globe of Mars.

We can also imagine beings chemically different from ourselves. The human flesh, like that of all other living beings (on the Earth), is a compound of carbon with hydrogen, nitrogen, and oxygen. By what authority do we condemn nature to abstain from creating, in other worlds, any other organic combinations than those of carbon ? Silicon, for instance : might this not have been the basis of another kind of organic protoplasm ?

The Universe is infinite. We are atoms.

Everything leads us to believe that the planet Mars, older than the Earth in chronologic order, more quickly cooled on account of its lesser volume, more advanced in its planetary life, is at present inhabited by beings more intelligent than we, and less imperfect. But what are they ? We need to be able to enter into telephotic communication with them. We do not despair of this, and we believe in progress.

C. FLAMMARION.